

# **Computer Aided Munitions Storage Planning**

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## **Background**

Even though munitions facilities are sited to the maximum afforded by the environment, storage facilities can be under-utilized because of inefficient storage planning. The limited munitions storage capability at most US Air Force bases requires that munitions facilities be utilized to their maximum sited capacity to provide operational readiness and flexibility to USAF operations.

The USAF Explosives Hazard Reduction Program is responding to a request from the Air Force Material Command and Hill AFB to develop a storage planning module for depot operations at Hill AFB. This system will be linked with the accountable system and provide a graphical storage management and planning interface, suggest re-warehousing options to maximize storage, and alert the user of violations, such as, quantity distance, compatibility, stack height, and security criteria.

Munitions storage planning is often accomplished with graph paper and pencil. The storage planner has many criteria to consider in addition to ensuring the material will actually fit inside the structure. A single incoming shipment can cause re-warehousing of several facilities, and periodic re-warehousing to optimize capacity may involve actions in every storage facility. Computerization of this process will expedite storage planning, reduce errors, and maximize storage facility utilization.

## **Introduction**

Computer aided storage planning systems can range from full-up artificially intelligent systems which would totally replace the storage planner to systems which are little more than text-based databases of storage locations. This paper presents a computer aided storage planning system which takes the middle ground. It describes a system which is not intended to replace the storage planner, but to be a tool that can allow storage planners to leverage their own knowledge and judgment in order to do their job easier and more efficiently.

Oftentimes, with text data, it is difficult to see the forest for the trees. The storage planner must interpret the location codes, munition size, compatibility codes, risk levels, and available

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space to decide where to place incoming munitions. Often, there will not be immediately available space, so the storage planner must decide what munitions need to be moved and where to move them in order to make room for other munitions. The storage planner is often reduced to pencil and paper, in order to visually make some sense of the mass of data available.

The key element of this system is the ability to inspect and manipulate the storage data both graphically and textually. This system combines the best features of both graphics and text. Graphics allow the user to immediately see the location, size, and relationship of munitions within a storage facility. These munitions are highlighted with patterns and colors to emphasize certain characteristics. Text windows list those elements of the facilities, munitions, and plans which are important, but would only clutter the graphics display. Also, some data is not represented well as graphics. The storage planner is able to receive the benefit of both type of data presentation in order to more effectively understand the storage data and produce a storage plan.

### **Storage Planning System (SPS) Description**

The key to the effectiveness of SPS as a storage planning tool is that it implements a dual approach to working with the munition data. The user can both graphically and textually inspect and manipulate the munition data. These two views of the data are synchronized to each other. The effect of this synchronization is that when the user changes something in one view, the other view is updated to reflect the change. In most cases, the user has the option to work with the data either graphically, textually, or both. Thus the user can choose which method works best in a particular situation. For instance, moving munitions from one location to another is probably best done graphically, by grabbing the munition and dragging it to a new location in the graphical view. However, the user could also key in the new location of the munition using the keyboard. In either case, SPS will update the alternate view to reflect the move. If the user dragged the munition in the graphical view, the location would update in the textual view. If the user keyed in a new location, the graphical view would reflect the munition's new location. However, some operations can only be done textually. For example, the user must use an input screen in order to enter the munition dimensions, risk category, stacking limits, clearances, and compatibility codes for a new munition which is not in the data base. This kind of data creation overwhelmingly drives one towards a textual interface.

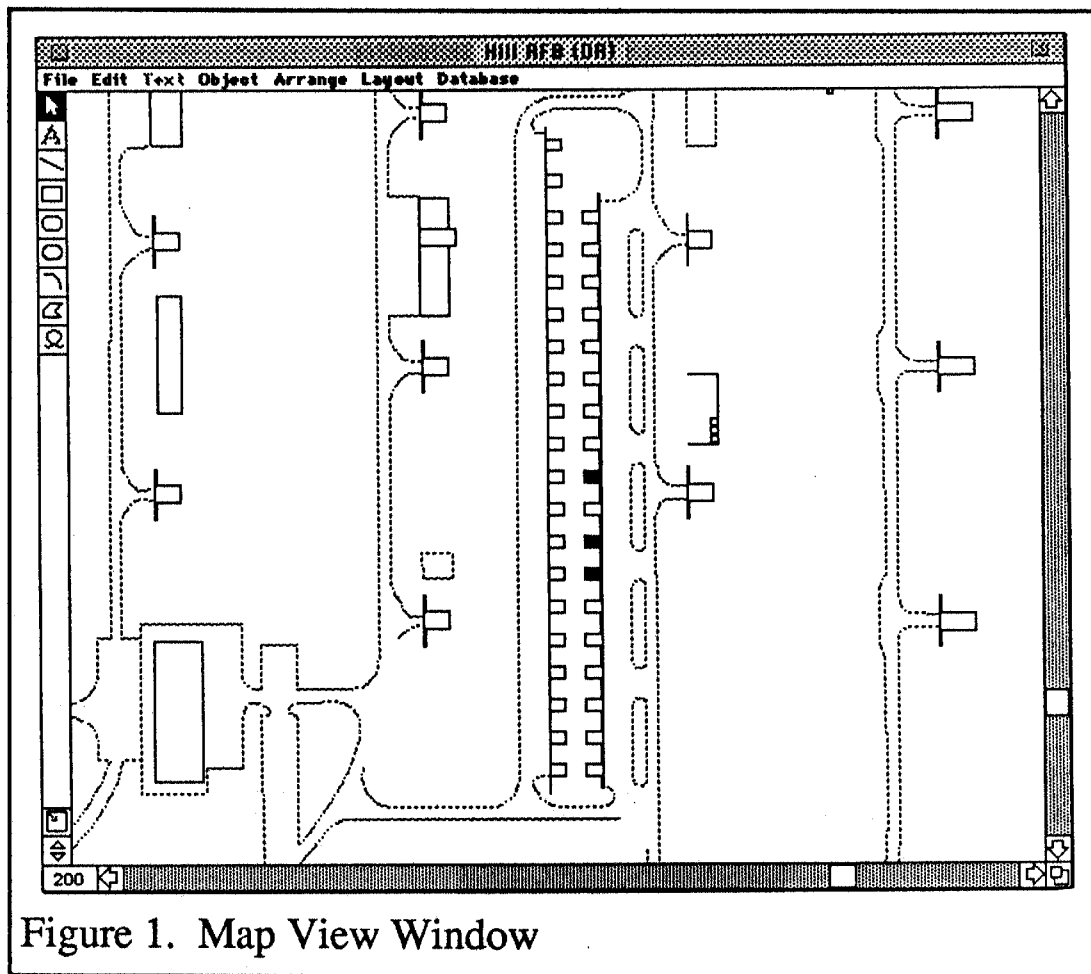
SPS provides several main benefits. First, SPS uses and displays the latest storage data downloaded from the base mainframe database called the Requirement Data Base (RDB). This database contains the locations of all munitions stored at Hill AFB and is used to generate all work orders moving munitions from one location to another. Thus, the RDB always has the best known information concerning munition locations. The user is freed from having to keep SPS updated, since SPS downloads the latest data from RDB. The second benefit to be gained is that the user can inspect and manipulate this data graphically. This allows the user to more effectively comprehend the munition data. The third benefit is that, as the user develops storage plans, SPS will alert the user to violations to storage restraints. These can take the form of alerting the user that munitions are being stored in incompatible

facilities, on incompatible stacks, in dead space or that the munitions exceed allowable explosive limits.

SPS uses a standard Macintosh interface and is implemented around a commercial relational database called 4th Dimension (4D). There are five major windows which present data the storage planner can use to produce a storage plan. These are the Map View, Facility View, Facilities List, Munitions List, and the Plans List. The first two are graphical views of the data and the last three are textual views of the data. The graphical and textual view are always synchronized with each other. This synchronization process will be explained in the following discussion.

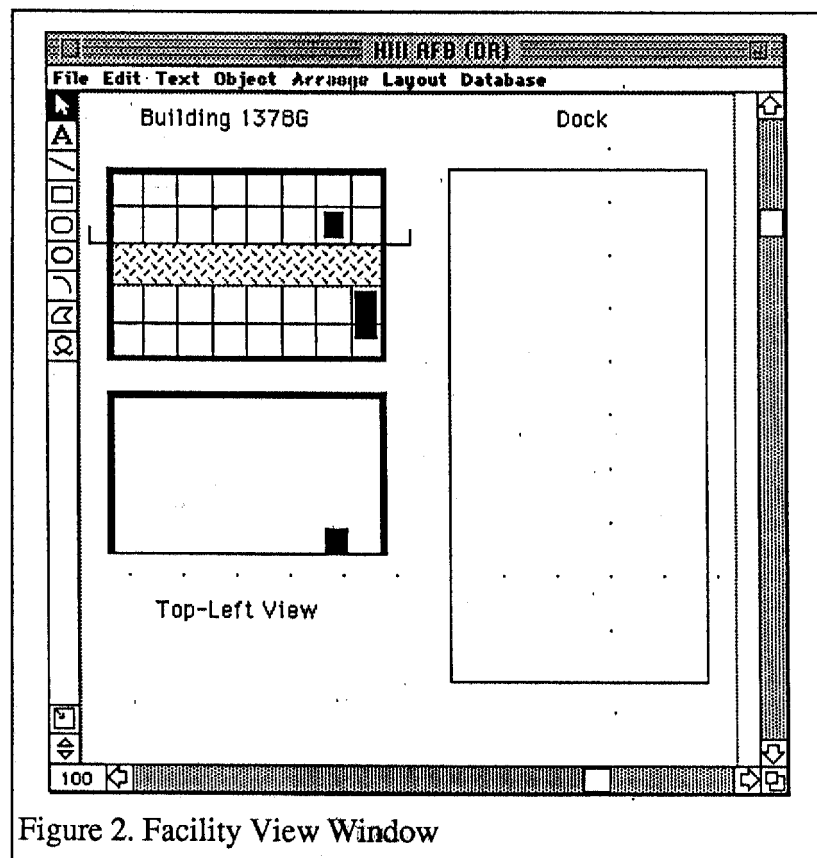
The Map View window shows a map of Hill AFB. Storage facilities, along with background information such as other buildings and streets are shown. Either the user or SPS can select and highlight any of the storage facilities. Figure 1 illustrates the facility map. Buildings which are filled with black are examples of highlighted storage facilities which have been selected by the user.

**Figure 1. Map View Window**



The facility is displayed in two views in the Facility View window. These two views can be either the Top-Front view, Top-Rear view, Top-Left view, or Top-Right view at the user's request. Within these two views, the facility, aisle space, location grid, dead space, reserved space, and munitions are displayed. Each of these can be shown or hidden at the user's discretion. The user may also set up cutaway views. Figure 2 illustrates a facility Top-Left view. Munitions which are filled with black are examples of munitions which have been selected by the user. In this figure, the user has selected a cutaway view which only shows munitions on the right side of the facility.

**Figure 2 Facility View Window**



**Figure 2. Facility View Window**

The Facilities List window lists information about each facility. This information includes the building number, facility type, risk level, high and low temperature limits, authorized NEW limits for each of 1.1, 1.2, 1.3, and 1.4 munitions. The present quantities are also listed. Figure 3 illustrates this list along with the various buttons that are available for further control of the Facilities List.

**Figure 3. Facility List Window. It has been Sectioned in three pieces to fit it in this illustration**

Facilities List								
BldgNum	FacType	Risk	HighTemp	LowTemp	AuthNEW 1.1	AuthNEW (04)1.2	AuthNEW (08)1.2	#
1378G	Igloo	U	100	0	300	250		100
1378H	Igloo	U	100	0	300	250		100
1378J	Igloo	U	100	0	300	250		100

Facilities List					
2	AuthNEW (12)1.2	AuthNEW (18)1.2	AuthNEW 1.3	AuthNEW 1.4	TotNEW 1.1
10	150	250	200	400	129
10	150	250	200	400	17
10	150	250	200	400	0

Facilities List							
.1	TotNEW (04)1.2	TotNEW (08)1.2	TotNEW (12)1.2	TotNEW (18)1.2	TotNEW 1.3	TotNEW 1.4	TotalNEW
129	0	0	0	0	0	1.6	130.6
17	0	0	0	0	0	0	17
0	0	0	0	0	403.8	0	403.8

Search...

List Munitions

List All

List Plans

Close

**Figure 3. Facility List Window. It has been sectioned into three pieces to allow it to fit in this illustration**

The Munitions List window lists information about each stored munition. This information includes the National Stock Number (NSN), lot number/serial number/date of manufacture, condition code, quantity, location, dimensions, nomenclature, required clearances, explosive class and division, IBD, net explosive weight (NEW), compatibility group, temperature requirements, risk category, and stacking data. Figure 4 illustrates this list along with the various buttons that are available for further control of the Munitions List.

**Figure 4.**  
**Munitions List Window. Sectioned into three pieces to fit this illustration.**

Munitions List								
NSN	Nomenclature		LotNum	SerialNum	DOM	BldgNum	Location	Clas.
1325-01-196-4533	Dispenser and Bomb, Aircraft			123-45-67		13780	001\001 A	
1325-00-489-1575	Computer Guided Bomb			145-98-65		13780	002\002 A	
1330-00-194-2768	Hand Grenade		1000			1378H	004\004 A	
1330-00-301-1990	Rifle Grenade		2500			1378H	007\001 A	
1370-00-077-8521	Aircraft Flare		3300			1378J	003\001 A	

Munitions List														
Class	Division	IBD	NEV	CompatGroup	RiskCat	Length	Width	Height	HighTemp	LowTemp	CondCode	Unit	Quantity	C
1	1			129 A	U	92	16	16	50	0		Container	1	
1	4			1.6 A	U	12	11	11.5	100	0		Container	1	
1	1			0.5 F	U	52	40	47	100	0 1		Box	20	
1	1			0.2 F	U	50	40	30	100	0		Box	10	
1	3			16.825 G	U	44	44	44	100	0 2		Pallet	24	

Munitions List									
	ClearFront	ClearRear	ClearRight	ClearLeft	Dunn1High	Dunn2High	Pall1High	Pall2High	STF
1	0	0	6	0	0	0	0	0	0.5
1	0	0	6	0	0	0	0	0	0.1
20	0	0	0	0	0	0	0	0	0.2
10	0	0	0	0	0	0	0	0	0.2
24	0	0	0	0	0	0	0	0	0.3

Figure 4. Munitions List Window. It has been sectioned into three pieces to allow it to fit in this illustration

The Plans List window lists each move in a storage plan. The information listed is the plan name, planner's name, munition identification, quantity, source location, and destination location. Figure 5 illustrates this list along with the various buttons that are available for further control of the Plans List.

**Figure 5. Plans List Window**

Plans List												
PlanName	Planner	PlanID	SrcHq	SrcLoc	DestHq	DestLoc	Completed	SeqNum	StartDate	StartTime	EndDate	EndTime
Plan Three	Sgt. S. P. Planner	104	18780	A001 A001 A	1878H	A005 A001 A	NotCompleted	1	5/15/94	14:00:00	5/15/94	15:00:00
Plan Three	Sgt. S. P. Planner	105	1878J	A003 A001 A	1878H	A006 A001 A	NotCompleted	2	5/15/94	15:00:00	5/14/94	16:00:00
<div> <input type="button" value="Search..."/> <input type="button" value="List Facilities"/> Criteria for choosing facilities and plans: <input type="text" value="Both Source and Destination"/> <input type="button" value="Select..."/> <input type="button" value="List Munitions"/> <input type="button" value="Close"/> </div>												

**Figure 5. Plans List Window**

Each of the graphical views can be used in conjunction with each of the list windows. The Map View window can be used with the Facilities List window.

The user can request that the list display only facilities which meet certain database criteria. For example, the user may request that only igloos containing less than 200 pounds of 1.1 and are temperature controlled be displayed. After the search, the list would only display the facilities meeting the criteria, and these facilities would be highlighted on the map. The user can also select certain facilities on the map, and the selected facilities would be listed in the Facilities List window. The user can also select facilities in the Facilities List window, and see these highlighted in the map. Thus the map and list stay synchronized. Another request the user may make at this level is to be shown all facilities which have space available and are compatible with an incoming shipment. SPS will highlight these facilities in the Facilities Map window and list them in the Facilities List window.

The Map View window can also be used with the Munitions List window. The user can request a list of munitions meeting certain database criteria. For instance, the user may request a list of all munitions which are of a certain lot number. SPS will display this list in the Munitions List and highlight those facilities containing these munitions in the Map View. The user can also select certain facilities in the Map View and the munitions in those facilities will be listed in the Munitions List. The user can also select certain munitions in the Munitions List and see the containing facilities highlighted in the Map View.

The Map View can be used with the Plans List in much the same way discussed above. Any selected facilities cause a list of those plans moving munitions into or from those facilities to be generated. Likewise, any selected plans will cause highlighting of applicable facilities.

When the Facility View is displayed, the same synchronization discussed above applies, but the various lists are limited to only that data which applies to the displayed facility. For instance, the Facilities List will only list data for the displayed facility. The Munitions List will only list munitions stored in the facility, and the Plans List will only list plans that either move munitions into or out of the displayed facility.

The Facility View is one of the most useful windows available to the storage planner. The user will see all the munitions stored in the facility. Any munitions not presently stored will be displayed in an area called the dock. The dock contains all incoming munitions, outgoing munitions, and munitions in transit between facilities. Since there can only be one facility view open at a time, this area will be used to move munitions from one facility to another. As the user moves munitions from one facility to another, a storage plan will be developed. A storage plan consists of a munition, a source location, and a destination location. The user can also add a date for the move if desired. A storage plan name will be associated with each move, so that all moves in a particular storage plan can be listed in the Plans List. As munitions are highlighted in the Facility View, those plans which move the selected munitions are listed in the Plans List window. Likewise, selecting plan moves in the Plans List, will highlight munitions in the Facility View. The 4D database can be used to select munitions or plans which meet user input criteria. The user will be able to select munitions in the dock, and request that SPS find available space to store those munitions. If space is not available, SPS will develop a suggested storage plan which will open up space to make room for the selected munitions, if possible. The facility view can also display reserved space and alert the user when this space is being used for munitions other than the intended munitions.

Synchronization also occurs between the various list windows. After choosing a selection of facilities in the Facilities List, the user can request that SPS display the Munitions List. This list will contain all the munitions in the selected facilities. This same type of synchronization will occur when moving from one list window to another.

The storage planner can perform what-if analysis with various storage plans. The user can instruct SPS to display the results of implementing a storage plan. SPS will then return to the baseline database as it was before the storage plan was used at the request of the user. In this manner, the user can try different storage plans to see which one meets requirement best.

SPS has other features . These include the ability to print reports based on the various list windows. For instance, the user can print a report of all storage facilities, total space available, total space used, and remaining space available. The space used can be broken into space used for each type of munition. Reports can be printed of all munitions and their locations. A storage plan can be printed to be handed to crew chiefs for implementation, including views of the facilities before and after the moves. Any storage plan can be uploaded to the RDB, and converted into work orders. The user can input certain preferences such as the line widths, colors, fill patterns and colors which SPS will use in the graphical views for displaying facilities, munitions, aisle space, reserved space, dead space and location grids.

## **Conclusion**

SPS is a powerful tool to help the storage planner better understand and manipulate munitions storage data. The storage planner can produce better storage plans more easily and more efficiently. The user can use the graphical view when it is more effective and the textural view when it is better. SPS augments, not replaces, the storage planner.

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